Water Use Efficiency as a Means of Up Scaling Carbon Flux from Leaf to Stand

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1. Introduction. The aim of this study is to assess the possibility to use instantaneous water use efficiency (WUE) as a means for up scaling leaf carbon uptake to forest stand scale. WUE is considered to be a conservative species property mainly dependent on vapour pressure deficit (VPD), and thus not reliant on light exposure. Here, we test if this holds for beech forest leaves at different heights of the trees, and thus different exposure to light.

2. Data. Leaf physiology were measured at different heights during the growing seasons of 1999 and 2000 in a Danish 80-years old beech (*Fagus sylvatica* L) forest, using an LCA-3 infrared gas analyser (ADC) with a Parkinson leaf chamber. Meteorological measurements above forest were used to assess WUE at dry days (2 preceding days without rain).

Figure 1. *Scaffold tower with the four height levels (24, 22, 18 and 12 m). During summer the lower levels are fairly dark.*

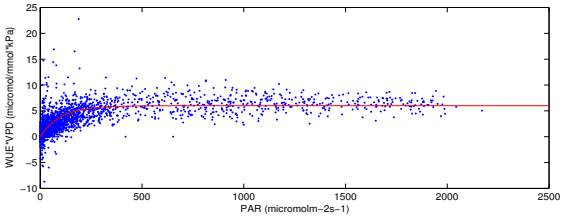

Figure 2. *WUE*VPD as a function of PAR using 2900 leaf physiology measurements.*

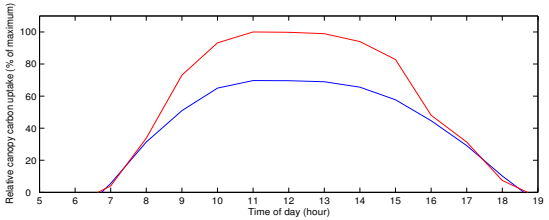

Figure 3. *Daily course of relative canopy carbon uptake modelled using constant (blue) and light dependent (red) WUE relationships.*

3. Method. WUE was estimated as the ratio between leaf net carbon uptake and leaf transpiration. WUE was found dependent on VPD and thus the relationship with photosynthetically active radiation (PAR) is determined for WUE*VPD. Whole tree carbon uptake was scaled up in two ways: 1. Constant relationship: average of all measurements. 2. Light dependent relationship based on a vertical leaf area distribution combined with a light distribution scheme.

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4. Conclusions.

- WUE is dependent of incoming PAR below 250µmol m^{-2} s^{-1} and, for the full range, dependent on VPD. No significant difference between different heights of the tree was found.
- Modelled WUE based on light dependency increase the estimated canopy carbon uptake compared to the average WUE. The relevance of average WUE requires that all leaves contributes equally to the total fluxes, which is not the case.
- Estimations of canopy WUE, using the average and the light reduced model, shows the same daily pattern as canopy WUE estimated from mast data, with a decreasing trend over the day.

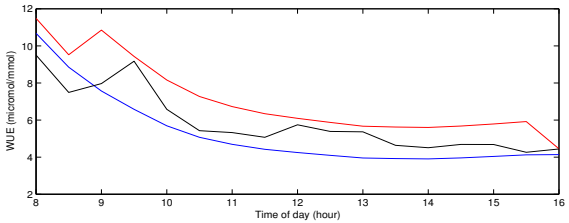

Figure 4. *Daily course of canopy WUE modelled using constant (blue) and light dependent (red) WUE relationships. Black: WUE estimated from carbon and water fluxes above forest.*

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